CONSTELLATION-X

SUBSYSTEM**:**   Optics Metrology

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DOCUMENT: D:\CXM_Metrology\Twist_Errors.doc

AUTHOR: W. Podgorski

DESCRIPTION: Analysis of Twist Errors

Summary

An analysis of optic twist error shows that this error should be limited to under 0.01 degrees, which reduces the sag measurement error to under 0.1µm (PV).
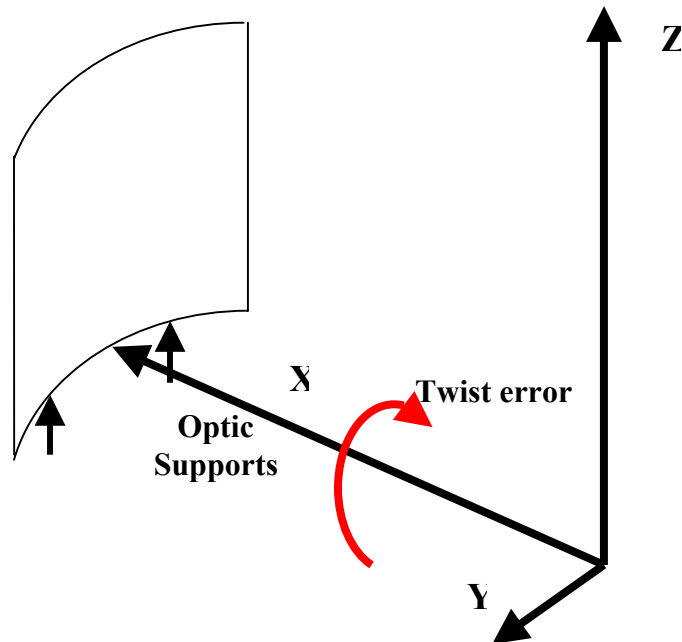
Analysis

Figure 1 – Twist Error

Analysis

A "twist" error is a rigid body rotation of the optic segment about a radius. This can be caused by vertical position errors in either of the two optic supports. A twist error causes the interferometer to scan a path which is not parallel to the optical axis. The effects of a twist error were modeled as follows:

- A 200mm tall cone was assumed, with a 240mm bottom radius and 0.41 degree cone angle.

- The optic rotates by 1 degree about a radius at the bottom of the optic, centered azimuthally. This is the X axis shown in Figure 1.

- Rotations about X displace the optic in the Y direction. These displacements range from 0.0mm at the bottom to 3.5mm at the top.

- The interferometer scans in a direction parallel to Z. Since the optic has rotated, the interferometer "sees" a surface at a distance which is in different from the original value, which was the perfect cone radius as a function of Z.

- The surface being seen now was originally at a rotation angle, θ, about the Z axis which is equal to:

$$\theta = \arctan(Z*\tan(\text{twist})/R(Z)) \text{ where } R = \text{radius as function of } Z$$

- The distance to the surface, D, as a function of Z is the original X value at the θ shown above, or:

$$D = R(Z)*\cos(\theta)$$

- The change in distance, ΔD due to the twist error is

$$\Delta D = D - R$$

This error, ΔD, is plotted in Figure 2 (red curve). It ranges from 0.0mm at Z=0 to 0.025mm at Z=200. A linear fit to this error was made and subtracted from it, yielding the residual shown in blue in Figure 2. This error is almost entirely 2nd order, with a P-V of about 6μm. To reduce the error below 0.1μm we need to reduce the twist error by a factor of about 100, or to 0.01 degrees. This requires a vertical support accuracy of about 0.02mm, since the 3 point mount supports are about 120mm apart.
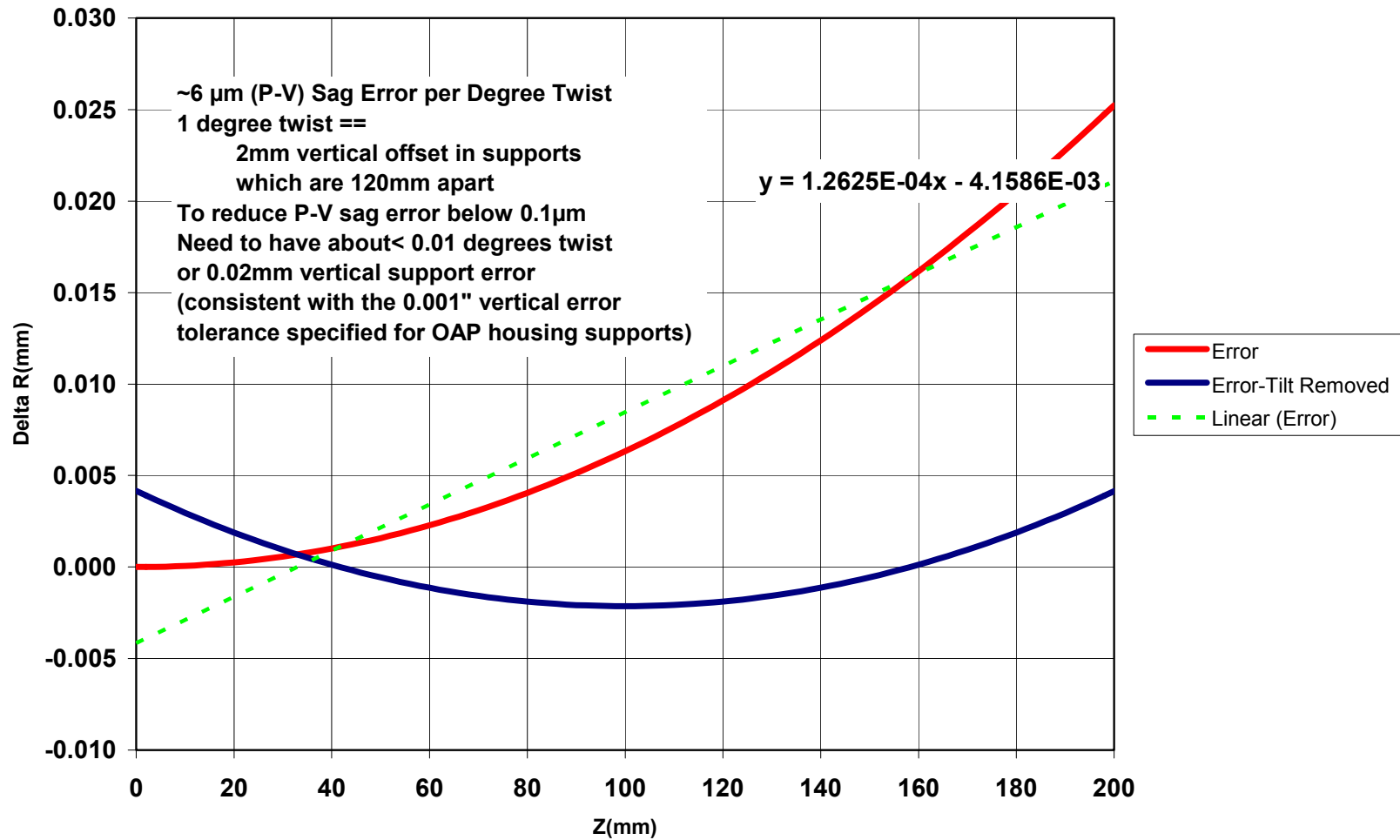
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Twist Error Sensitivity

Figure 2 – Twist Error Sensitivity